3.0 OPERATIONS

3.1 Site Facilities

The Ponce Municipal Landfill site covers an area of 51 ha (125 acres) of which about 21 ha (52 acres) is currently subject to landfilling operations. The site is bounded by a 2.1 m (7 feet) chain link fence except for two short stretches where the topography provides a natural barrier. Access to the site is on the east side via Avenue Baramya, Barrio La Cotorra.

Site facilities are mainly located near the entrance gate and include:

1. Gate House - provides all weather enclosure for checker to evaluate incoming refuse, check weight, handle billing and provide directions. A first aid kit is maintained at this location.

2. Truck Scale - allows determination of weight of refuse delivered to site.

3. Office Trailer - provides office space, restroom and storage; first aid kit maintained here.

4. Public Disposal Containers - four open top roll-off containers with a raised ramp access are provided near the entrance gate to provide disposal to small vehicles. This reduces the traffic at the active fill area and promotes safe operations by segregating private and commercial vehicles.

3.2 Nature of Wastes

3.2.1 Current Practice

The site receives approximately 350 to 450 tonnes (400 to 500 tons) of refuse per day. The majority of this refuse is domestic waste from the entire island. Metal waste and demolition debris are also received at the site. Nominal quantities of car bodies and other metal objects (such as appliances) are crushed prior to disposal.

The site also currently receives between 15 and 30 kL/day (4000 and 5000 gallons/day) of high organic sludge, mixed with solid refuse, from tuna processors in the area. At present the site cannot accept more than 80 kL/day (25,000 gallons/day) of tuna sludge without solidifying the sludge prior to disposal.

The site also accepts small quantities of industrial waste from petrochemical and pharmaceutical industries. These mainly comprise off-specification products and are only accepted only after laboratory approval to ensure that they are not hazardous materials as defined in 40 CFR 261.

Some asbestos waste and waste water treatment sludge are also received at the site and are managed according to applicable state and federal regulations.

3.2.2 Previous Practice

During the 1970's two small synthetically-lined evaporation lagoons were operated on the western side of the site by SK & F Industries. These lagoons were clean-closed and covered in 1983. A study by Recra Research, Inc. (1984c) documented the removal of the sludge and the closure of the lagoons and listed the major hazardous constituents of the sludge within the lagoon as being:

- heavy metals (barium, chromium, copper, iron, nickel, silver and zinc);
- halogenated organics;
- soluble organic carbon;

- o sulfide; and
- o cyanide.

Following removal of sludge and effected soil, sulfide and cyanide were detected above background level in soil remaining beneath the lagoons. However, the risk of these constituents affecting surface water and groundwater were considered very low since the surface has been capped with low permeability material (Recra Research, Inc., 1984c) and the depth to groundwater is on the order of 300 feet.

The possible existence of hazardous wastes at the site was investigated by Law Engineering and Testing Company (1983d). The results of this work are discussed in Section 5.

3.3 Equipment

A fleet of heavy earthmoving equipment is maintained at the site to facilitate spreading and compacting of refuse, excavation and transporting, and spreading of cover material. Equipment currently in use at the site includes:

- o two Caterpillar D8 bulldozers used for spreading and compacting refuse and excavating cover material;
- o one Caterpillar 966 wheel loader used for loading cover material;
- o one Mack dump truck used for hauling cover material;
- o one Mack truck fitted with an 11 kL (4000 gallon) water tanker used for dust suppression;
- o one Caterpillar 120 grader used for road maintenance;

- one John Deere 690 backhoe used for general duties around the site (i.e., drainage maintenance and solidification); and

- other miscellaneous support equipment.

3.4 Method of Placing Refuse

General municipal refuse brought to the site is placed directly on the landfill. Each day, refuse is placed in several compacted layers 0.2 to 0.35 m (8 to 14 inches) thick to achieve a maximum thickness for the day of 2.4 to 3.3 m (8 to 10 feet). On any given day, refuse is placed over a roughly rectangular area with minimum plan dimension of 15 to 20 m (50 to 60 feet) and maximum plan dimension of 20 to 30 m (60 to 100 feet). At the end of each day, the refuse is covered with 0.15 to 0.3 m (6 to 12 inches) of soil. Each day's refuse is placed over the previous days to form a series of contiguous cells as shown in Figure 9. The cells combined together form a terrace that is graded to promote surface drainage.

Logged and manifested industrial wastes are disposed of separately in dedicated trenches within the landfill, always located downwind from each day's main operating face. Trenches are backfilled at the end of each day's operations. Industrial wastes disposed in this manner include tuna processing sludge, non-hazardous petrochemical and pharmaceutical waste and asbestos. When necessary, liquid wastes are solidified with kiln dust prior to disposal. Such liquid wastes include high organic sludge from tuna processing plants, municipal sludge mixed with soluble oil from aluminum can companies, sludge from food products, and some hydrocarbons.

3.5 Cover

Cover material is obtained from both the Ponce and Juana Diaz Formations (i.e., both north and south of the main fault which transects the site). After excavation and compaction, soils from these sources can generally be described as follows:

- cover from Ponce Formation - generally silty sand or sandy silt, sometimes clayey.
- cover from Juana Diaz Formation - generally sand clayey silt, sometimes silty or sandy clays.

Soil cover is placed as follows:

- 0.15 m (6 inches) daily cover
- 0.3 m (12 inches) intermediate cover
- 0.6 m (24 inches) final cover

Daily cover is applied at the end of each working day to provide control of insects and rodents, to reduce odor and retain refuse, to prevent fire and to improve appearance.

Intermediate cover is placed on areas that will not receive additional refuse or final cover for 30 days or more.

Final cover is applied to areas which have received refuse up to the final design grade.

Intermediate or daily cover material is taken typically from stockpiles adjacent to the working face spread over the exposed refuse, and compacted with the bulldozer.

3.6 Leachate Management

Site personnel in the past have only observed seepage from the landfill after periods of heavy rainfall, such as during the 100 year flood condition in October, 1986. Because seepage occurs so infrequently, no specific measures have been implemented to manage leachate at the site.

4.0 SURFACE HYDROLOGY

4.1 Hydrology

The drainage basins encompassing the Ponce Landfill Site are shown on Figure 8. There are no lakes within the site nor rivers or streams flowing through the site. Runoff from surrounding areas onto the site is negligible.

Approximately 90 percent of the site area drains to the Rio Pastillo to the east with the remainder draining to the Quebrada del Agua which flows west and south of the site. Most of the drainage flow to the Rio Pastillo is via the valley to the east of the site.

The limits of the 100 year flood plain are also shown on Figure 8. The site is at least 0.5 km (1/3 mile) from the limit of the flood plain.

4.2 Surface Runoff Control

The landfill is located within a natural valley which drains eastward to the Rio Pastillo. The surface of the landfill is shaped so that virtually all runoff water will flow to the east. Recent filling towards the northern side of the site and quarrying activities outside the northeastern corner of the site have resulted in a surface profile which would allow a small amount of northward drainage from the site and then possible eastward drainage towards the Rio Pastillo.

Ditches and other conveyance structures are present on site to promote drainage off and around the landfill area. These drainage features and the fill contours promote drainage away from the fill. Virtually all surface flow and sediment which leaves the site must do so through the gully to the east of the site.

These drainage features have flow only during periods of significant precipitation at the site.

5.0 INVESTIGATIONS OF LANDFILL AND WASTE

5.1 General

Several investigations have been performed at the site which provide useful information on the characteristics of the landfill. These investigations documented in Recra Research, Inc. (1984b) and Law Engineering Testing Company (1983a, b, c and d) include:

- Seismic refraction transversing performed across and near the edge of the landfill,
- Several phases of geotechnical borings which penetrated through the landfill. A series of borings were drilled by Law Engineering Testing Company (1983d) specifically to investigate the nature of the landfill. These borings, referred to as CA-1 to CA-8, are shown on Figure 9.

A summary of the soil boring data for the site, including information relevant to the landfill, the alluvium, and the underlying residual soils, appears in Table 1.

5.2 Landfill

The data presented in Table 1 have been used to prepare isopachs of landfill thickness (Figure 10). These isopachs indicate a maximum fill thickness of 35 m (115 feet) on the northern side of the site. The data from Table 1 have also been used to prepare isopleths of elevation of the base of the landfill (Figure 11). These show a topographic low running from northwest to southeast across the center of the valley with a gradient of 2° to 3°.

The waste-fill encountered in the investigation was predominantly municipal-type refuse mixed with a soil of varying types. The municipal refuse was composed largely of wood, paper and fabric. The soil cover consisted of the Ponce and Juana Diaz Formation materials as previously described in Section 3.5.

Borings CA-1, CA-2, and CA-3 were located in areas where the potential existence of buried non-municipal type refuse was considered most likely. Boring CA-1 was drilled in an area in which burial of asbestos-containing materials was suspected. The materials sampled from this boring were predominantly paper, wood and cardboard wastes similar to that encountered elsewhere on the site. Borings CA-2 and CA-3 were drilled in areas where aerial photographs had indicated liquid waste disposal. On the basis of visual examination of the samples, no hazardous wastes were encountered in these borings. Analytical results for samples from these borings are discussed in subsequent paragraphs.

In boring CA-2, a zone of very high gas production was encountered at 13.4 to 14.0 m (44 to 46 feet) below ground surface. Explosive gases (presumably methane) were detected with an explosimeter as far as 4.5 m (15 feet) downwind of the boring location, with explosive concentrations being measured as far as 1.2 m (4 feet) from the borehole. In boring CA-3, a zone of wastes from tuna processing was encountered. These wastes were identified by their unusual texture and very strong odor. However, the quantity of explosive gas detected by explosimeter from this zone was relatively small. Explosive gas was also observed in many other borings drilled in the landfill, as indicated in Table 1.

Saturated conditions in the waste-fill were encountered in many of the borings, as noted on Table 1. In the CA-series of borings specific information on local saturated zones was observed, indicating variable depths to saturated zones and variable thickness of saturated zones. In some cases, saturated conditions were observed near the base of the landfill just above the top of the underlying residual soil. No hydraulic interconnections were noted on the boring records between separate, identifiable saturated zones.

Samples of the landfill obtained from the CA-series borings were submitted for chemical analyses. Samples collected from a roadway excavation in the landfill were also submitted for chemical analyses. The results of chemical analyses from these samples are presented in Tables 2 and 3.

The summary of analytical results presented in Table 2 show that the materials analyzed are representative of ordinary sanitary landfill refuse. From this data it is noted that total cyanide results for composite samples COMP-CD-8 and COMP-CD-9 are elevated with respect to the results for other composites. Total barium results for all samples are high. Polychlorinated biphenyls were detected in COMP-CD-4 at levels just above detection. This composite sample was obtained from materials sampled at boring CA-2, which was drilled in an area suspected of having received liquid wastes.

The analytical results from the roadway samples shown in Table 3 indicate that none of the materials sampled would be classified as hazardous wastes. The results are not unusual for common sanitary landfill refuse containing industrial residues. Differences within the data exist; several parameters detected in composite samples COMP-RW4 and COMP-RW5 are elevated with respect to results for the other composites. Given the methods of disposal common to sanitary landfills, the variability of analytical results should be anticipated.

5.3 Soil Beneath Landfill

Most of the borings drilled in the landfill penetrated underlying alluvium and residual soils by about 1.5 m (5 feet). Brief descriptions of the soils encountered below the landfill are presented in Table 1. The thickness of the alluvium encountered in borings is also shown on Figure 11. Following are significant observations from these borings:

- the alluvium is confined to a localized area towards the eastern side of the site and is mainly comprised of soils with significant clay or silt content;
- the residual soils derived from the Ponce Formation are more variable comprising both predominantly clayey soils and predominantly sandy soils;
- leachate staining was observed in the residual soils of the Juana Diaz to a maximum depth of 0.5 m (18 inches) although in most borings no staining was observed; and
- leachate staining was observed in the residual soils of the Ponce Formation encountered in Boring CA-7.

6.0 SLOPE STABILITY

6.1 Stability of Natural and Cut Slopes

The stability of slopes cut in the Ponce and Juana Diaz Formations is largely governed by structure within the rock, i.e., strength and orientation of bedding surfaces, faults and other joint surfaces. With the data available, analysis of stability of the natural slopes is not possible. It is clear, however, that instability of natural slopes is not a common occurrence in the area, even under earthquake loading. The risk of natural slope failure at the site is considered to be very low.

Law Engineering Testing Company (1983a) reviewed slope stability conditions in the area and reported that the occurrence of landslides were not mentioned in any of the geologic literature reviewed during their study. Slopes are generally moderate, except in areas of excavation , and there are no thick sequences of unstable clayey material. No natural talus deposits were mapped at the site or seen on aerial photographs of the general area.

Formation of cut slopes at angles greater than the natural slope requires evaluation. Two steep cut slopes which exist at the site were assessed by Davisson (1984a and b). These cuts, one on the north side of the site and one on the south side of the site, are noted on the Site Plan (Figure 2).

In his assessment of the cut slope on the north side of the site, Davisson concluded that the slope was stable under static load conditions and dynamic loading from an earthquake with a horizontal acceleration of 0.13 g. However, he concluded that the fault-bounded rock wedge that encompasses a large portion of the southern cut slope was only marginally stable under static conditions and likely to be unstable under earthquake loading. Davisson recommended that this slope be flattened prior to constructing any site facilities below the slope.

6.2 Stability of Landfill

There are two potential mechanisms of instability in the landfill:

- Large scale sliding on the base of the landfill or on weak layers within the landfill.
- Outside slopes of the landfill.

The risk of the first of these failure mechanisms occurring is extremely remote. The base of the landfill is relatively flat with a gradient of 2° or 3° dipping to the southeast. The possibility of sliding on this base angle is extremely remote. Furthermore, the landfill is largely constrained by the shape of the valley walls which effectively encircle the landfill with a small down-gradient opening on the east side of the site.

The possibility of large-scale low-angle failure through weak layers within the landfill is also remote since the landfill is heterogeneous and extensive weak planes on which failure could occur are unlikely to exist.

Failure of the outside slopes of the landfill is the only mechanism of failure which could possibly occur. In general, side slopes on the landfill are no steeper than 1V:3H (i.e., about 18°) and slopes are no higher than about 15 m (50 feet). These slopes are within the limits of normal landfill practice. Furthermore, there have never been any signs of instability in the side walls of landfill at the site. Even if minor failure occurred under earthquake loading, the consequences of such failure would be minimal since any exposed refuse could be quickly recovered.

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SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
C-1	83.5	NE	NE	NE	NE	NE	59	Sandy Silty Clay (JD), Stained	
C-2	81.0	NE	NE	NE	NE	NE		Clayey Silty Sand (P)	
C-3	49.7	45	4.7	NE	NE	NE	26	Sandy Clayey Silt (JD)	
C-4	91.4	NE	NE	NE	NE	NE	44	Sandy Silt followed by Sandy Silty Clay (JD)	
C-5	90.5	NE	NE	NE	NE	NE	61	Sandy Silt (JD)	
C-6	80.5	67	13.5	NE	NE	NE	38	Sandy Silt Clay (P)	
C-7	77.0	NE	NE	NE	NE	NE		Sandy Silty Clay (JD)	
C-7A	88.0	NE	NE	NE	NE	NE		Sandy Clayey Silt (JD)	
C-8	89.0	NE	NE	NE	NE	NE		Sandy Silty Clay (JD)	
C-9	135	NE	NE	NE	NE	NE		Silty Sand (P)	
C-10	130.4	NE	NE	NE	NE	NE		Sandy Clayey Silt (P)	
C-11	51.3	42	9.3	40.2	1.8	Silty Clay		Sandy Silty Clay (P)	Explosive Gases Present
C-12	52.0	42	10.0	41.2	0.8	Silty Clay		Clayey Silty Sand (P)	Explosive Gases Present
C-13	50.0	42	8.0	41.8	0.2	Slightly Clayey		Clayey Sandy Silt (P)	Explosive Gases Present

TABLE 1
(Page 2 of 9)

SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
						Sand			
C-14	48.0	40	8.0	38.7	1.3	Silty Clay		Silty Clayey Sand (P)	Explosive Gases Present
C-15	85.0	NE	NE	NE	NE	NE	3	Silty Clayey Sand (P)	
C-16	66.5	NE	NE	NE	NE	NE	37		
C-17	89.5	84	5.5	84.0	0	Sandy Clayey Silt	Perched Water at 84.5		Explosive Gases Present
C-18	89.0	82	6.0	NE	NE	NE	Perched Water at 84.0		Explosive Gases Present
C-19	92.0	NE	NE	NE	NE	NE			Explosive Gases Present Note : Stopped at Anger Refusal
C-19A	92.0	85	7.0	NE	NE	NE			
C-20	88.6	82	6.6	NE	NE	NE	Perched Water at 84.6		Explosive Gases Present Hydrogen Sulfide Present
C-21	91.1	83	8.1	NE	NE	NE			Explosive Gases Present
C-22	79.7	77	2.7	NE	NE	NE			Explosive Gases Present
C-23	79.1	73	6.1	NE	NE	NE		Clayey Sandy Silt (JD)	Explosive Gases Present
C-24	82.0	79	3.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present

TABLE 1
(Page 3 of 9)
SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
C-25	80.0	75	5.0	NE	NE	NE		Sandy Silty Clay (JD), Top 0.5m Stained	Explosive Gases Present
C-26	76.7	71	5.7	NE	NE	NE		Silty Clay (JD), top 1m stained	Explosive Gases Present
C-27	74.0	70	4.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-28	72.0	64	8.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-29	79.0	68	11.0	NE	NE	NE		Sandy Silty Clay (JD)	
C-30	67.0	64	3.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-31	83.0	80	3.0	NE	NE	NE		Silty Clayey Sand (JD)	
C-32	79.7	74	5.7	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-33	83.0	76	7.0	NE	NE	NE		Sandy Silty Clay (JD), 1.5m stained	Explosive Gases Present
C-34	76.4	73	3.4	NE	NE	NE		Sandy Silty Clay (JD), 0.5m stained	Explosive Gases Present
C-35	76.0	NE	NE	NE	NE	NE			Note: Boring Terminated at 1m
C-36	76.2	NE	NE	NE	NE	NE			Note: Boring Terminated at 1m

TABLE 1

SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
C-37	77.5	73	4.5	NE	NE	NE		Silty Clay (JD)	
C-38	75.0	72	3.0	NE	NE	NE		Sandy Silty Clay (JD)	
C-39	85.0	NE	NE	NE	NE	NE		Sandy Silty Clay (JD), stained joints	
C-40	82.0	NE	NE	NE	NE	NE			Note: Boring Terminated at 1m
C-41	70.1	NE	NE	NE	NE	NE		Silty Clayey Sand (JD)	
C-42	69.0	NE	NE	NE	NE	NE		Silty Clayey Sand (JD)	
C-43	64.9	64	0.9	NE	NE	NE		Silty Clayey Sand (JD)	
C-44	82.9	NE	NE	NE	NE	NE		Sandy Silty Clay (JD)	
C-45	80.0	74	6.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-46	67.0	52	15.0	NE	NE	NE		Sandy Silty Clay (JD), 1m stained	Explosive Gases Present
C-47	81.0	79	2.0	NE	NE	NE		Sandy Silty Clay (JD), Stained Joints	Explosive Gases Present
C-48	62.0	54	8.0	NE	NE	NE		Silty Clayey Sand (JD)	Explosive Gases Present
C-49	55.0	52	3.5	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-50	58.5	NE	NE	NE	NE	NE		Sandy Silty Clay (JD)	

TABLE 1
(Page 5 of 9)
SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
C-51	58	56	2.0	NE	NE	NE		Sandy Silty Clay (JD)	
C-52	NE	NE	NE	NE	NE	NE			Note: Not Drilled
C-53	76.0	55	21.0	NE	NE	NE			Explosive Gases Present
C-54	70.9	52	18.9	NE	NE	Slightly Sandy Clay	Perched Water at 63.9		Explosive Gases Present
C-55	64.2	48	16.2	46	2.7	Sandy Clay		Sandy Clay (JD)	Explosive Gases Present
C-56	75.0	59	16.0	NE	NE	NE		Sandy Clay Silt (JD)	Explosive Gases Present
C-57	NE	NE	NE	NE	NE	NE			Note: Not Drilled
C-58	74.8	65	9.8	NE	NE	NE			Explosive Gases Present
C-59	NE	NE	NE	NE	NE	NE			Explosive Gases Present Note: Drilled to Refusal
C-59A	70.8	53	17.8	NE	NE	NE	Perched Water at 66.8 -62.8 and 56.8	Sandy Silty Clay (JD) Clayey Sand Lenses	Explosive Gases Present
C-60	64.0	51	13.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-61	74.5	68	6.5	NE	NE	NE		Sandy Silty Clay (JD),sand stringers	Explosive Gases Present
C-62	NE	NE	NE	NE	NE	NE			Note: Drilled to Refusal

SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
C-62A	69.8	62	7.8	NE	NE	NE		Sandy Clayey Silt (JD)	Explosive Gases Present
C-63	66.3	56	10.3	NE	NE	NE		Sandy Silty Clay (JD), Stained	Explosive Gases Present
C-64	64.0	55	9.0	NE	NE	NE		Sandy Clayey Silt (JD)	Explosive Gases Present
C-65	78.0	NE	NE	NE	NE	NE		Clayey Sandy Silt (JD)	
C-66	74.0	63	11.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-67	68.8	NE	NE	NE	NE	NE		Sandy Silty Clay (JD)	
C-68	NE	NE	NE	NE	NE	NE			Note: Not Drilled
C-69	NE	NE	NE	NE	NE	NE			Note: Not Drilled
C-70	NE	NE	NE	NE	NE	NE			Note: Not Drilled
C-71	43.5	45	Thrown Out	NE	NE	NE		Silty Sand (P)	
C-72	45.0	44	1.0	NE	NE	NE		Clayey Silty Sand (P)	Explosive Gases Present
C-73	47.4	44	3.4	11.6	32.4	Sandy Clay		Sandy Silty Clay (JD)	Explosive Gases Present
C-74	49.5	42	7.5	NE	NE	NE	Perched Water at 46.5 and 44.5	Silty Clayey Sand (JD)	

TABLE 1

SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
C-75	50.8	45	5.8	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-76	53.6	50	3.6	NE	NE	NE		Silty Clayey Sand (JD)	Explosive Gases Present
C-77	56.7	50	6.7	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-78	62.0	55	7.0	NE	NE	NE		Sandy Silty Clay (JD)	Explosive Gases Present
C-79	NE	NE	NE	NE	NE	NE			Note: Not Drlled
C-80	NE	NE	NE	NE	NE	NE			Note: Not Drlled
C-81	58.5	48	10.5	NE	NE	NE	Perched Water at 55.5	Sandy Silty Clay (JD)	Explosive Gases Present
C-82	55.5	48	7.5	46.6	1.4	Sandy Silty Clay		Sandy Clayey Silty (JD)	
C-83	47.8	46	1.8	NE	NE	NE		Silty Clay Sand (JD)	
C-85	62.6	NE	NE	NE	NE	NE			
LAGOON BORINGS									
C-86	NE	NE	NE	NE	NE	NE			Note: Not Drilled
C-87	76.4	NE	NE	NE	NE	NE		Sandy Silty Clay (P)	

SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
CA-1	83.2	71	12.2	NE	NE	NE	Perched Water at 82.2 and 72.2		Explosive Gases Present
CA-2	83.8	NE	NE	NE	NE	NE	Perched Water at 14m		Explosive Gases Present Note: Anger Refusal at 70m
CA-3	93.0	70	13.0	NE	NE	NE	Perched Water at 82.0		Explosive Gases Present
CA-4	99.8	64	35.8	NE	NE	NE			
CA-5	93.0	65	28.0	NE	NE	NE	Perched Water at 90.0		Explosive Gases Present
CA-6	77.1	72	5.1	NE	NE	NE	Perched Water at 76.1		Explosive Gases Present
CA-7	85.0	52	33.0	NE	NE	NE			Explosive Gases Present
CA-8	68.4	63	5.4	NE	NE	NE	Perched Water at 67.4		Explosive Gases Present
C-84	78.0	NE	NE	NE	NE	NE			
C-88	100.3	NE	NE	NE	NE	NE			
C-89	122.2	NE	NE	NE	NE	NE			
C-90	115.5	NE	NE	NE	NE	NE			

TABLE 1
(Page 9 of 9)

SUMMARY OF BORING DATA

LEGEND: NE= None Encountered JD= Juana Diaz Formation P= Ponce Formation

Borehole #	Surf. El. * (MSL) (m)	Landfill Base El. (MSL) (m)	Landfill Thick (m)	Alluvium Base El. (MSL) (m)	Alluvium Thick (m)	Alluvium Description	Ground Water Elevation (m)	Residium Description	Comments
C-91	132.5	NE	NE	NE	NE	NE			
MW-5	57.8	43	14.8	41.7	1.3	Sandy Silty Clay	Possible Perched Water at 43m		Explosive Gases Present
MW-6	76.8	74	2.8	NE	NE	NE			

Note: * As of 2/9/88

TABLE 2

SUMMARY ANALYTICAL RESULTS FOR LANDFILL COMPOSITES

Parameter	Unit of Measure	Comp-CD-2	Comp-CD-4	Comp-CD-6	Comp-CD-8	Comp-CD-9	Comp-CD-10	Comp-CD-11	Comp-CD-12	Comp-CD-13	Comp-CD-14	Comp-CD-15	Comp-CD-16
		SAMPLE IDENTIFICATION											
Chemical Oxygen Demand	g/g Dry	5,700	7,800	9,000	21,500	55,300	27,100	53,300	17,100	163,000	12,800	24,700	4,010
Total Recoverable Phenolics	g/g Dry	2.27	2.03		0.82			1.15	2.09	2.89			
Total Recoverable Oil & Grease	g/g Dry	2,280	330	1,400	21,000	3,300	2,280	7,090	1,740	8,330	33,700	18,800	54,400
Total Cyanide	g/g Dry		0.76	0.72	1.97	2.28				0.93	0.77	1.43	1.22
Total Barium	g/g Dry	76	110	204	228	120	133	244	153	113	45		250
Total Zinc	g/g Dry	34	204	24	46	149	50	72	84	52	24	42	4.7
Halogenated Organic Scan (ECD)	*		0.76		0.10	0.10				0.23			
Total Poly-chlorinated Biphenyls	**		0.17 0.34 0.41										

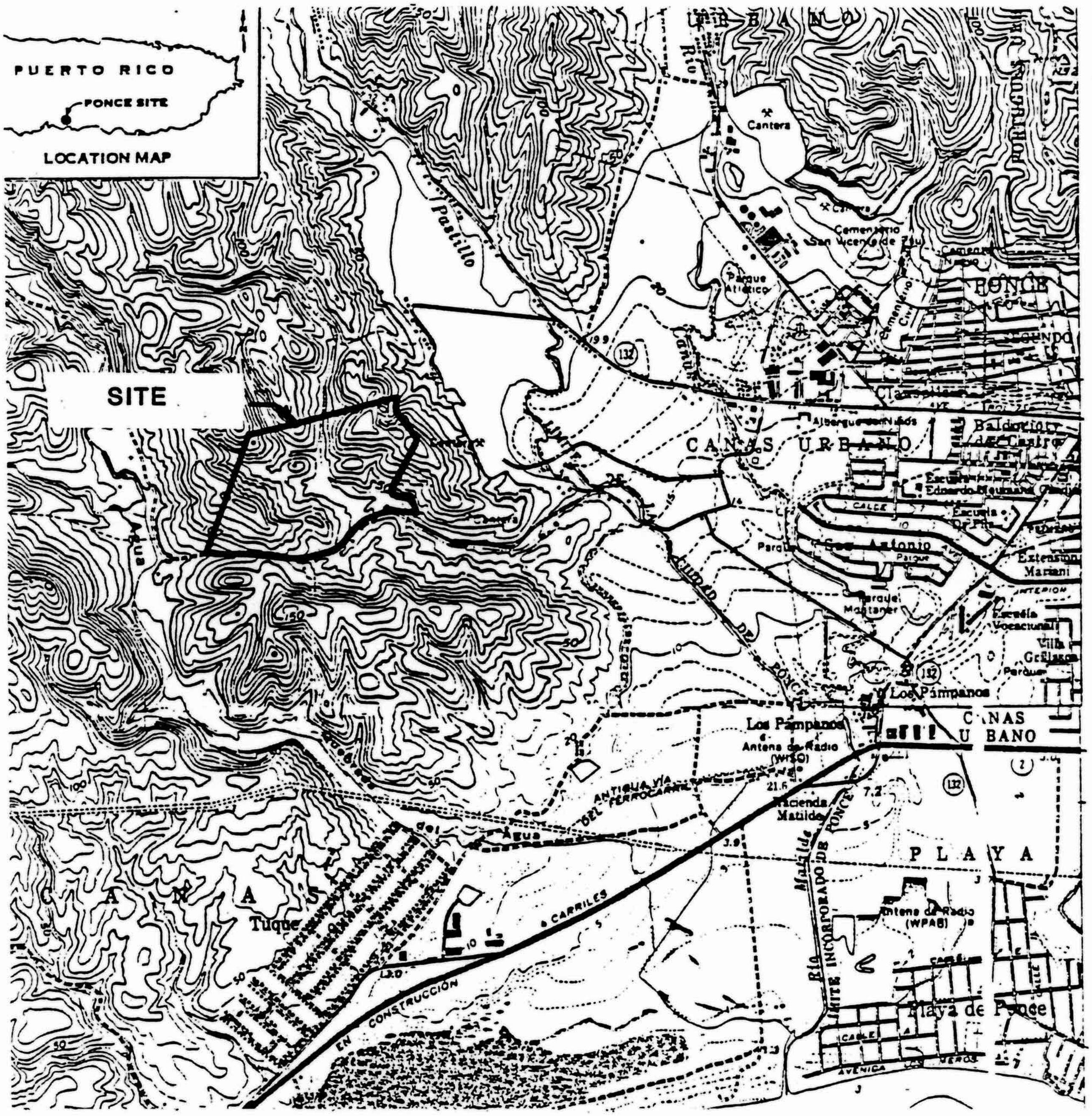
* ug/g dry as Chlorine;
Lindane Standard

** ug/g dry as Aroclor 1242
ug/g dry as Aroclor 1260
ug/g dry Total

TABLE 3

SUMMARY OF ANALYTICAL RESULTS
FOR THE
ROADWAY SIDEWALL COMPOSITES

Parameter	Unit of Measure	SAMPLE IDENTIFICATION								
		COMP-RW 1	COMP-RW 2	COMP-RW 3	COMP-RW 4	COMP-RW 5	COMP-RW 6	COMP-RW 7	COMP-RW 8	COMP-RW 9
Total Cyanide	ug/g Dry	1.5	2.0	--	13	33	1.2	0.51	0.63	--
Leachable Organic Carbon	ug/g Dry	490	830	420	1,300	2,500	470	810	380	400
Leachable Sulfide	ug/g Dry	36	400	180	1,370	1,330	140	51	210	1,200
Halogenated Organic Scan (ECD)	ug/g Dry As Chlor. Lindane Std.	0.1	0.20	0.13	1.0	23	0.12	--	0.13	0.55
EP Toxicity Test Extracts										
Total Arsenic	mg/l	0.043	0.110	0.043	0.036	0.029	0.033	0.029	0.033	0.026
Total Barium	mg/l	1.3	1.1	1.4	1.0	1.3	1.2	1.3	1.1	1.3
Total Cadium	mg/l	0.009	--	--	--	--	--	--	--	--
Total Chromium	mg/l	0.036	0.026	0.053	--	--	0.023	--	0.060	0.028
Total Lead	mg/l	0.095	0.064	0.100	0.036	0.088	0.023	--	0.033	0.100



LEGEND

— 100 — TOPOGRAPHIC CONTOUR INTERVAL = 10 METERS

REF:

TAKEN FROM USGS PENUELAS (1964)
& PUNTA CUCHARA (1964) TOPO QUAD MAPS.

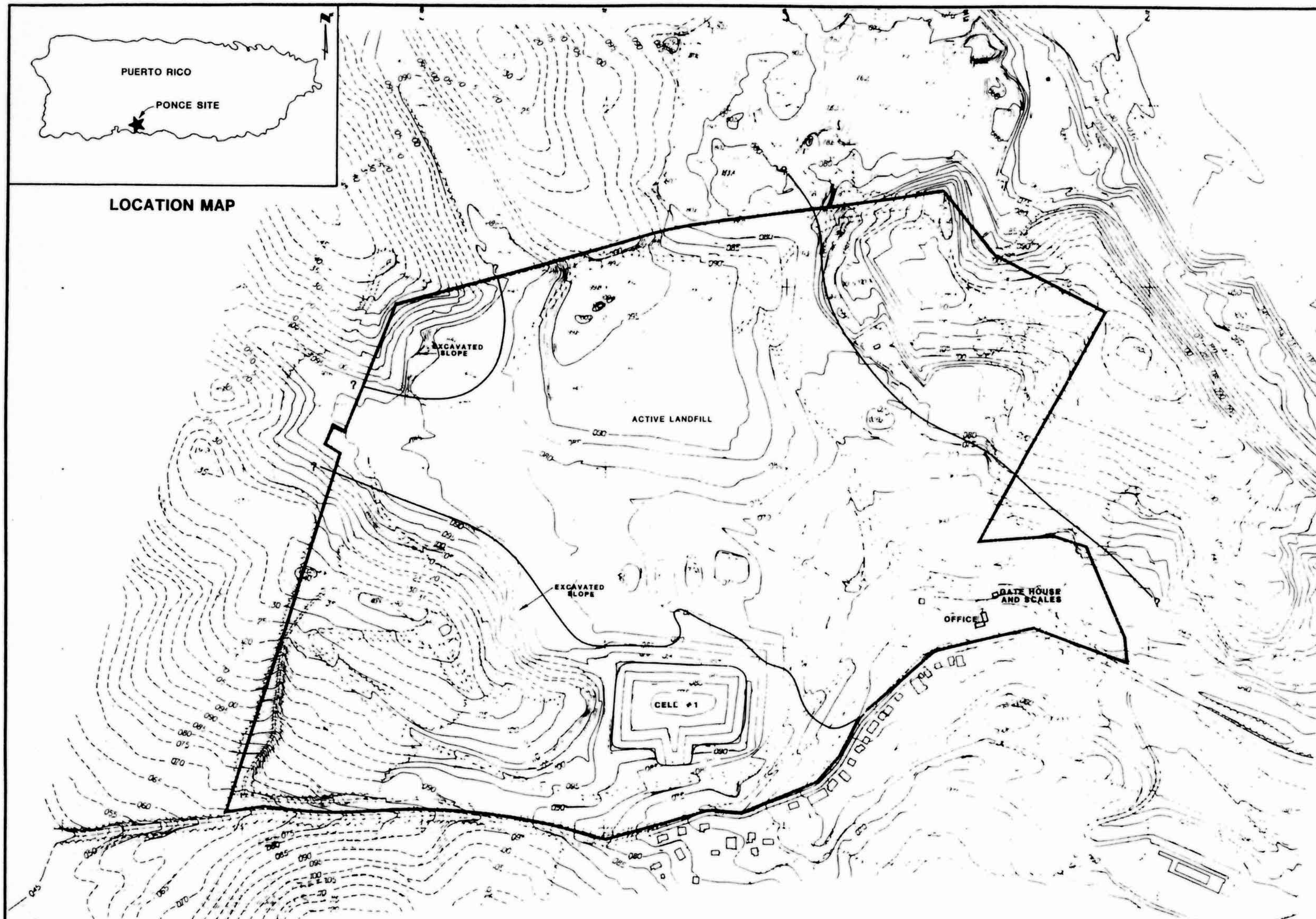
MILES 0 — 1

KILOMETER 0 — 1

SCALE

Golder Associates, Inc. Atlanta, Georgia	TITLE SITE LOCATION MAP FOR PONCE MUNICIPAL LANDFILL	
CLIENT/PROJECT BFI OF PONCE, INC.	DATE 6/25/88	SCALE AS SHOWN	JOB NO. 883-3643
DRAWN DRC	CHECKED SDS	REVIEWED WRS	FILE NO. 883-3643	DWG. NO. / REV. NO. 2	FIGURE 1

5



LEGEND

- APPROXIMATE BOUNDARIES OF LANDFILL CONTOUR INTERVAL: 1 METER
- SITE BOUNDARY
- 100 TOPOGRAPHIC CONTOUR = 1 METER INTERVALS

NOTE:
BASE MAP PREPARED FROM FEB.,1988 AERIAL PHOTOS

SCALE IN METERS
50 0 50 100 150
1:2000

REVISIONS		
DESCRIPTION	BY	DATE

BFI OF PONCE, INC.

TITLE: SITE PLAN FOR PONCE MUNICIPAL LANDFILL

DRAWN	DRC	SCALE	AS SHOWN	DATE	[illegible]
CHECKED	SDS	REVIEWED	WRS	JOB NO.	[illegible]
Golder Associates				DWG NO.	2
				FIGURE	2

ATTACHMENT 4

HYDROGEOLOGIC REVIEW
RCRA FACILITY ASSESSMENT
PONCE MUNICIPAL LANDFILL
PONCE, PUERTO RICO

July 1988

883-3643

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Golder Associates Inc.

CONSULTING ENGINEERS

July 22, 1988 883-3643

Browning-Ferris Industries
of Ponce, Inc.
P.O. Box 3151
Houston, Texas 77254

Attention: Mr. Bruce Jernigan
Divisional Vice President

RE: REPORT ON HYDROGEOLOGIC REVIEW
RCRA FACILITY ASSESSMENT
PONCE MUNICIPAL LANDFILL
PONCE, PUERTO RICO

Gentlemen:

We are pleased to submit the following report on the Hydrogeologic Review, RCRA Facility Assessment, for the Ponce Municipal Landfill.

We appreciate the opportunity to assist BFI on this project.

Very truly yours,

GOLDER ASSOCIATES, INC.

W. R. Sullivan

W. Randall Sullivan, P.E.
Associate

WRS/r

EXECUTIVE SUMMARY

This report presents the results of a review of hydrogeologic conditions for the Ponce Municipal Landfill, Ponce, Puerto Rico. The site is located 1 to 2 km (0.6 to 1.2 miles) outside the city limits of Ponce, and 3 km (1.8 miles) north of the Caribbean Sea. The site covers an area of 51 ha (125 acres) of which approximately two-thirds is occupied by mainly municipal refuse and fill. Quarrying operations and disposal of refuse have been occurring in the area since before 1967.

The site is located in a valley surrounded by rugged hills. Topographic elevations range between 40 m and 140 m (130 and 450 feet) MSL. Climatic conditions in the area are characterized by high temperatures, moderate but variable rainfall and high evapotranspiration. There are no lakes or streams within the site boundaries and most site rainfall run-off is to the east into the Rio Pastillo.

Groundwater in the vicinity of the site in the Upper Plains is primarily derived from the alluvial soils and the Ponce Formation, whereas in the Coastal Plain and Coastal Flat, groundwater is almost totally derived from the alluvial soils (McClymonds, 1972). The City of Ponce, located in the Coastal Plain, relies on groundwater from wells tapping the coastal alluvial deposits for agricultural, industrial, public supply, and domestic use, (McClymonds, 1972).

Large variations of groundwater quality are found in the Ponce Formation. The Ponce Formation water samples have a high calcium and magnesium content, probably the result of formation solutioning. In some places, in the Ponce limestone, where solution channels exist and the formation is overlain by alluvium, large quantities of fresh water can be obtained. Generally, the total dissolved solids content of water from the Ponce averages about 1,000 mg/L (McClymonds, 1972).

Groundwater in the Juana Diaz Formation is of poor quality, which contains high mineralization especially sulfates and chlorides. This may be due, in part, to the long residence time of groundwater in the Juana Diaz Formation. A representative value of total dissolved solids content of water from the Juana Diaz is about 5,930 milligrams per liter (mg/L) according to the U. S. Geological Survey (McClymonds, 1972).

The site is transected by an east-west trending fault zone which has a major impact on-site geologic and hydrogeologic conditions. To the north of the fault, the site is underlain by the Ponce Formation which consists of fossiliferous vuggy limestone. To the south of the fault, the site is underlain by the Juana Diaz Formation with a thin capping of lower stratigraphic Ponce Formation at higher elevations. The Juana Diaz Formation consists mainly of fine grained calcareous mudstone with thin clayey and sandy interbeds. Bedding dips to the south at about 20 to 30 degrees. Investigations at the site have shown that the continuity of bedding is disrupted by numerous faults within the Juana Diaz Formation.

The east-west trending fault which transects the site appears to splay into two faults towards the eastern side of the site. Within this fault zone, there appears to be a thin capping of Ponce Formation overlying the Juana Diaz Formation.

Comparison of current landfill surface elevations with base of landfill elevations from previous drilling investigations indicate that the maximum thickness of landfill is 35 m (115 feet). The landfill consists of municipal-type refuse mixed with earthen cover of varying soil type. Chemical analyses of landfill samples indicate variable compositions typical of municipal-type refuse. Saturated zones have been observed at various levels within the landfill.

Evaluation of data from soil borings indicate that the near-surface alluvial soils and residual material of the Juana Diaz Formation have low hydraulic conductivity. The limited information available for the Ponce residual material indicates that it has high hydraulic conductivity.

The available data for the site indicate that the Juana Diaz and Ponce Formations behave as different groundwater regimes separated by the east-west trending fault which acts as a flow barrier. Thus, groundwater occurs in three separate regimes:

- groundwater in the Juana Diaz Formation;
- groundwater in the Ponce Formation; and
- saturated zones in the landfill.

The Juana Diaz Formation is hydrogeologically complex. The available data indicate that groundwater occurs under semi-confined and unconfined conditions in southerly dipping strata of variable hydraulic conductivity which have been disrupted by faulting. Groundwater levels in monitoring and observations wells occur at differing elevations irrespective of the level of the well screen. It, therefore, appears that the faults within the Juana Diaz Formation are acting as barriers to flow, isolating fault-bounded blocks from each other, and isolating the Juana Diaz at the site from the regional groundwater system. Groundwater age dating and chemical analyses of the Juana Diaz groundwater further support the concept of the faults acting as groundwater flow barriers.

Only limited information is available on hydrogeologic conditions within the Ponce Formation. This information indicates that groundwater occurs at an elevation generally at about 30 meters (100 feet) lower than in the adjacent Juana Diaz Formation. The Ponce Formation at the site exists under unconfined conditions and is believed to be connected to the regional groundwater system. Hydraulic conductivity of the Ponce Formation is expected to be high given the occurrence of solution cavities.

The results of the hydrogeologic review indicate that there is little likelihood of leachate from the landfill reaching groundwater within the Juana Diaz Formation. Although the hydrogeologic model for the Juana Diaz Formation is complex and there are some areas of uncertainty, it is apparent that there is very little flow into or out of the formation. Evidence for this is:

- The variable potentiometric levels over short distances, and the corresponding steep hydraulic gradients, imply that the faults act as groundwater barriers.
- Age dating of groundwater from the Juana Diaz Formation indicates that it is old groundwater, of the order of a few thousand years and is, therefore, not being significantly recharged.
- Evapotranspiration in the Ponce area is very high and this, combined with the typically low hydraulic conductivity of the Juana Diaz Formation, indicates that there will be little recharge from surface water.

Although the Juana Diaz Formation is complex, further characterization of the formation is not considered necessary. Downward migration of leachate into the Juana Diaz Formation is unlikely because of its low hydraulic conductivity. Leachate encountering the surface of the Juana Diaz is expected to flow laterally downhill along the soil-landfill contact. The travel route of the leachate would generally be to the east, controlled by the east-west trending valley at the site. A surface monitoring station will be established at the eastern portion of the site in a remnant stream valley to monitor any leachate seepage.

Since downward flow into the Juana Diaz is unlikely to be a pathway for leachate migration from the sanitary landfill, no monitoring wells are proposed in the Juana Diaz. Browning-Ferris Industries of Ponce, Inc. is currently developing a separate monitoring program for Cell 1 that may include monitoring wells in the Juana Diaz Formation.

Only limited information is available to characterize the hydrogeology of the Ponce Formation. However, it is considered to be a potential pathway for migration of leachate via both downward seepage to the water table and lateral seepage within the fault splay above the Juana Diaz Formation. Further characterization of the hydrogeologic conditions within the Ponce Formation is recommended. It is proposed that this be achieved through installation of six monitoring wells which should also provide the basis for a long term monitoring system.

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